BEH
Bulletin épidémiologique hebdomadaire

InVS
INSTITUT DE VEILLE SANITAIRE

20 March 2012 / N° 12-13

Special issue - Identify and monitor health impacts of climate change in the context of adaptation

Scientific coordination of the issue: Mathilde Pascal, Institut de Veille Sanitaire, Saint-Maurice, France and, from the BEH editorial board: Dorothée Grange, Observatoire Régional de Santé d'Île-de-France and Agnès Lefranc, Institut de Veille Sanitaire, Saint-Maurice, France

The French version of this issue is available in PDF format at : http://www.invs.sante.fr/Publications-et-outils/BEH-Bulletin-epidemiologique-hebdomadaire/Derniers-numeros-et-archives/Archives/2012/BEH-n-12-13-2012

We wish to thank Farida Mihoub for her support with the translations.

Editorial

Alexandre Magnan

Institut du développement durable et des relations internationales (IDDRI), Sciences Po, Paris

More than twenty laboratories throughout the world are now developing new climate scenarios in order to feed the Fifth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC) that is planed for 2014. We can expect therefore that in the next few years, climate science will refine its simulations and propose a much more precise view of the future in terms of the evolution of the main climate parameters (averages, extreme events) and of associated impacts at regional and local levels. Public and private actors from various fields, including social-health, need these assessments and evaluations to implement anticipatory action. Consequently, there is a strong temptation to wait until these outputs become available. However, apart from the certainty that climate change is real, many scientific and methodological challenges remain. They take the form of uncertainties (about specific trends, about local impacts, etc.) that cannot be reduced rapidly. It is necessary therefore to take action now. This implies to clearly understand why climate change will affect the future living conditions of societies all over the world, as it is this understanding that will inform future anticipatory actions (see the articles by P. Pirard *et al.* and D. Bitar *et al.* in this issue).

Climate change must not only be seen as a modification of the atmospheric and oceanic conditions on a global level. Doing so would mean disconnecting climate change from the realities of a health service provided in any given hospital, from social and healthcare administrations, from NGO humanitarian activities, etc. Instead climate change should be regarded as a "chain of impacts". The disruptions to the climate system are going to be seen in the evolution of some of the main parameters (temperature, precipitation and sea-level), which will affect the frequency, the intensity and the geographical distribution of natural hazards. These latter will themselves have varying degrees of impact on natural resources (health, agriculture, energy production, etc.). This chain of impacts can and must be tackled now, despite the context of uncertainty. This is the idea advocated in this current issue of the BEH.

More specifically, this issue shows that between climate variability (evolution of climate parameters around their averages) and climate change (evolution of these averages over several decades at least), health conditions are going to be affected. Although there are many unanswered questions, researchers and actors in the field are mobilizing to identify, understand and measure these changes. This work is all the more complicated because at first glance (and generally) the research carried out faces certain contradictions. This situation is illustrated in this issue of BEH as follows: on the one hand we ask whether a drop in mortality in the Northern hemisphere is to be expected, given the future increase in average temperatures, and knowing that - except in the case of exceptional heatwaves - the mortality rate is higher in the Northern hemisphere during winter than during the rest of the year (P. Kinney *et al.*); on the other hand, we notice that the number of epidemics in Europe has increased in the last decades, a trend which is strongly correlated to greater climate variability (S. Morand *et al.).* Of course each kind of disease will react differently to climate stress and to different socioeconomic and geographic contexts. The fact remains that the analysis of the impacts of climate change often involves the comparison of hypotheses that are a priori contradictory. However, most of the time these contradictions are only surface deep, and in order to clarify them, analyses focusing on the conditions and scales (social, spatial and temporal) of diseases development are needed. Moreover, these analyses support anticipatory approaches.

An important area of social-health research focuses on "surveillance systems", the benefits of which are already known. They will continue to be the pillars of anticipation, and therefore, of adaptation to climate change (M. Pascal *et al.*). An example of this is provided in this issue. The article by S. Morand *et al.* focuses especially on risk factors (biodiversity, climate variability, development level, human infectious diseases) that help measure exposure levels (identified and potential) to epidemics and identify levers to reduce their consequences. Other avenues could also be explored, notably an analysis of populations' adaptive capacity. This concerns both the ability to react to a crisis when it occurs (resilience) and to collectively accepting the efforts brought about by long-term prevention policies (anticipation).

How to cite this article: Magnan A. Editorial. Numéro thématique - Identifier et surveiller les impacts sanitaires du changement climatique pour s'y adapter. [Special issue - Identify and monitor health impacts of climate change in the context of adaptation]. Bull Epidémiol Hebd. 2012;(12-13):145-6.

Editor's note

There are some special peculiarities in this issue of BEH, linked directly to the primary topic discussed. Despite the fact that the international scientific community recognizes the reality of climate change, there remains much uncertainty regarding the nature and magnitude of these changes and their environmental consequences. In turn, the identification of the health consequences of these changes is problematic, and remains necessarily prospective, if not speculative. Accordingly, the articles presented in this issue aim to carry out a forecasting exercise, by presenting the scenarios deemed by the authors to be most probable, given today's available scientific knowledge. They are different therefore from the articles usually published in BEH, in terms of form and content. Nevertheless, this work is an indispensable prerequisite for the analysis of the adaptations to be carried out on existing health surveillance and response systems.

What are the health impacts of climate change and what role does surveillance play?

Mathilde Pascal (m.pascal@invs.sante.fr), **Sylvia Medina, Anne-Catherine Viso, Pascal Beaudeau**

Institut de Veille Sanitaire, Saint-Maurice, France

Abstract

Observations and climate models enable us to better understand present and future climate changes. Climate change may be considered as a factor of change in the environment, in the determinants of exposure to environmental risks and pathogens, and possibly in the state of health among populations. In this context, health surveillance systems have three main objectives: 1) creating databases to increase scientific evidence and understanding the health impacts of climate change in the long term; 2) identifying, prioritizing, implementing and evaluating intervention and adaptation measures; and 3) providing early warning measures. Although it is not necessary to create new health surveillance systems to fulfil these objectives, there is a need both for better integration with existing environmental and health surveillance, and for greater interdisciplinarity.

Keywords

Climate change, health impact, health, surveillance

Health impacts of climate change

Climate change refers to a statistically significant change in the average climate or in its variability which continues over long periods (generally over decades or longer). Although temperature is the emblematic variable in climate change, all climate parameters (humidity, cloud cover, precipitation, increased CO2 levels in the atmosphere etc.) may be concerned.

In 2007, on the basis of observations, the intergovernmental panel on climate change (IPCC) [1] concluded that the average temperatures in the Northern hemisphere during the second half of the 20th century were very probably (probability>90%) greater than those for any 50-year period during the last 500 years. While cold days, cold nights and frost are now likely to be less frequent in most continents, the opposite can be said for warm days and warm nights. It is possible (probability >66%) that heat waves have become more common in most continents. More than 8 in 10 experts agree on the fact that the natural systems associated with snow, ice and frozen ground, as well as the hydrological systems are already impacted by climate change. Moreover, more than 9 in 10 experts estimate that many terrestrial and marine ecosystems have already been affected [1].

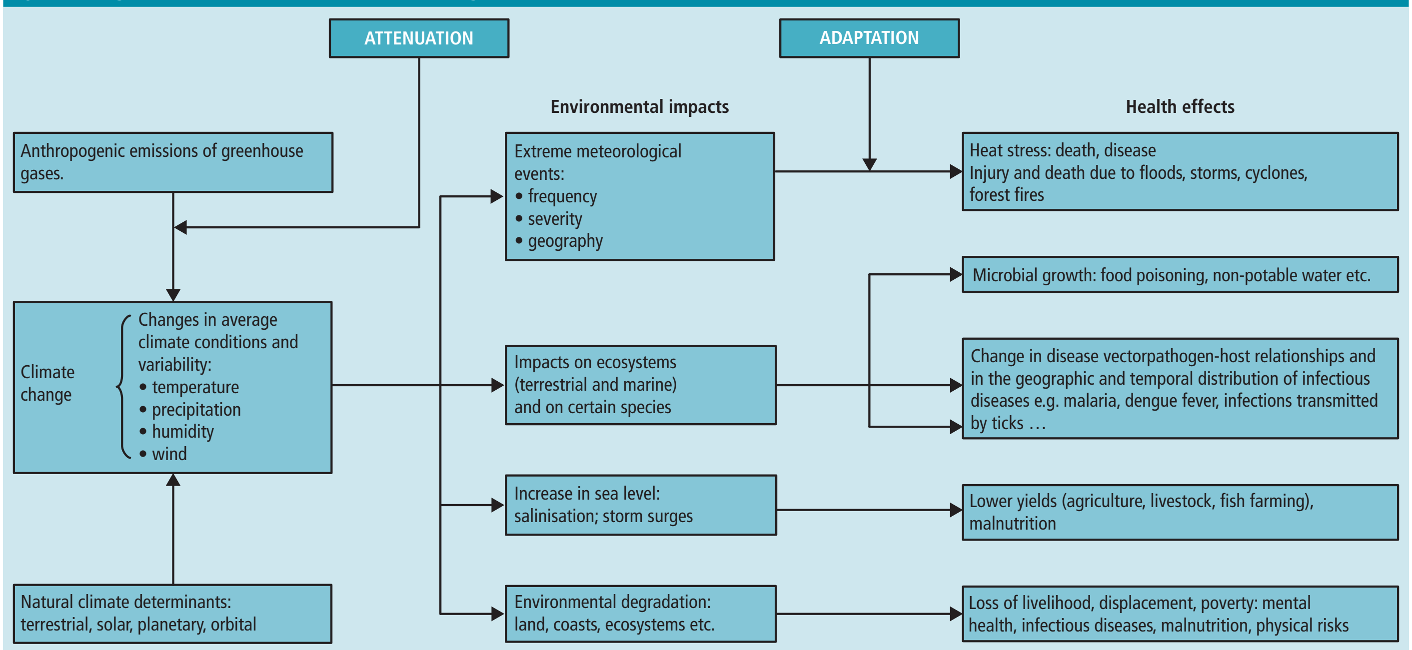
Climate models help to predict future climates by focusing on scenarios of the evolution in greenhouse gas emissions. While these models have not yet been perfected, it would appear that the reality of climate change has now been accepted. The simulated increase in average temperature from now until 2100 using various climate models ranges from 1,1°C to 6.4°C [1]. In mainland France, according to a high-end scenario, the average temperature would increase by 0.83°C [0.55°C-1.24°C] in 2030 with respect to 1990 and by 1.37°C [0.85°C-1.8°C] in 2050 [2].

These observed and predicted changes are going to modify the environment, the determinants of exposure to environmental and infectious risks, and possibly the state of health of the population. The potential impacts on health have been highlighted since 1985, in particular stressing the risks associated with heat and food supply [3]. However it was not until the 2000s that a wider vision on the relationship between climate change and health became available (Figure 1) [4], stressing three types of impact: [4-9]:

- The impacts of extreme meteorological events which are likely to increase in frequency and intensity: heat waves, floods, storms, forest fires, episodes of drought, etc.;
- The emergence or re-emergence of infectious diseases, associated with modifications in ecosystems;
- A change in exposure to environmental risks (air, water, UV radiation, food etc).

Although developing countries are the most vulnerable [6], assessments carried out in France [10;11], Europe [4;8;9], North America [12;13] and in Australia [14] underline the fragility of developed countries when faced with extreme events, the greatest recognized risk being that associated with heat waves. For the other types of impact (infectious and environmental), it remains difficult to make any hypothesis on the changes to come, given the complexity of the interactions between system variables and uncertainties about the rate of climate change as well as other changes (demographic, social, etc.).

Figure 1 **Diagram of the links between climate change and health (from [4])**



The results from research should provide new elements of understanding in the coming years.

How can surveillance systems be adapted?

Despite these uncertainties, it is important to proactively adapt society and the health sector in order to limit the negative impacts of climate change [15]. Public health surveillance, that is to say, "the ongoing, systematic collection, analysis and interpretation of health data essential for the planning, implementation and evaluation of public health practices, closely associated with the timely dissemination of these data to those who may need them" [16], provides useful information for the orientation of adaptation strategies. Environmental health surveillance, which includes the surveillance of pathologies, environmental risks, exposure and exposure-risk relationships, is of primary concern.

Surveillance-based data therefore has three principal roles: 1) creating databases to increase scientific evidence and understanding about the health impacts of climate change in the long term; 2) identifying, prioritizing, implementing and evaluating intervention and adaptation measures; and 3) anticipating new threats.

The most successful example of such surveillance regards the risk of a heat wave: mortality data enable retrospective analyses over several decades to be carried out. A morbidity database is currently under construction at the French Institute for Public Health Surveillance (Institut de Veille Sanitaire - InVS) using the Sursaud®[1] surveillance system. Moreover the national heat wave plan[2] was designed in 2004, then evaluated and amended from surveillance and epidemiological studies.

In terms of the other risks, the InVS evaluated the adaptation needs for its own surveillance systems in mainland France [10], and in this context, organized a workshop [17] which brought together professionals in surveillance from several countries. The discussions resulting from this workshop led to the development of a simple approach to identify the adaptation needs of surveillance systems. It consists in identifying the principal environmental, social and demographic determinants which contribute to exposure. When applied to health risks likely to be modified by climate change, it helps identify the gaps and missing data in surveillance, and consequently associated needs. The underlying idea is that it may be more informative and practical to implement surveillance of a determinant which is not directly associated with climate than to investigate a meteorological indicator (e.g. monitoring vulnerability to heat waves) [17;18].

The risks taken into account in our approach include those for which published data on climate impact exist, and those whose risk of occurrence in France was deemed likely by a internal InVS working group [10;18]. At the end of this review, we concluded that although it is not necessary to create new surveillance systems to monitor the health impacts of climate change, it is nevertheless important to guarantee the sustainability and quality of existing systems. Opportunities for development were also identified, for example, the possibility of collaboration with experts on climate modeling, with a view to evaluating the impacts of atmospheric pollution on health.

To conclude, surveillance adaptation will come about through better integration between existing environmental and health surveillance systems, as well as greater interdisciplinarity: with climate and environmental sciences, as well as social sciences for a better understanding of behaviors; with natural scientists and veterinarians to observe the evolution of parasites and disease vectors; and with health professionals to identify and interpret unexpected signals.

[1] http://www.invs.sante.fr/Espace-professionnels/Surveillance-syndromique-SurSaUD-R

[2] http://www.sante.gouv.fr/canicule-et-chaleurs-extremes.html

References

[1] Solomon SD, Quin D, Manning M, Chen Z, Marquis M, Averyt KB, *et al.* Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, 2007. Cambridge, United Kingdom and New York, NY, USA: Cambridge University Press; 2007. 996 p.

[2] Observatoire national des effets du réchauffement climatique. Climat futur en France. Site internet Onerc. http://www.onerc.org

[3] Lawrence Berkeley Laboratory. Characterization of information requirements for studies of CO_2 effects: Water resources, agriculture, fisheries, forests and human health. Washington, D.C: Margaret R. White 1985. 236 p.

[4] McMichael AJ, Woodruff RE, Hales S. Climate change and human health: present and future risks. Lancet. 2006;367(9513):859-69.

[5] World Health Organization - Regional Office for Europe; Santé Canada; United Nations Environment Programme; Organisation Météorologique Mondiale, (dir.). Methods of assessing human health vulnerability and public health adaptation to climate change. Copenhagen: WHO Regional Office for Europe; 2003. 112 p.

[6] Costello A, Abbas M, Allen A, Ball S, Bell S, Bellamy R, *et al.* Managing the health effects of climate change: Lancet and University College London Institute for Global Health Commission. Lancet. 2009;373(9676):1693-733.

[7] A Commission on climate change. Lancet. 2009; 373(9676):1659.

[8] Haines A, Kovats RS, Campbell-Lendrum D, Corvalan C. Climate change and human health: impacts, vulnerability, and mitigation. Lancet. 2006;367(9528):2101-9.

[9] Parry ML, Canziani OF, Palutikof JP, van der Linden. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. IPCC: United Kingdom and New York, NY, USA; 2007. 976 p.

[10] Pascal M. Impacts sanitaires du changement climatique en France, quels enjeux pour l'InVS. Saint-Maurice: Institut de veille sanitaire. 2010; 54 p. Available at: http://www.invs.sante.fr/pmb/invs/(id)/PMB_721

[11] Observatoire national des effets du réchauffement climatique. Impacts du changement climatique, adaptation et coûts associés en France - rapport d'étape. Paris: Observatoire national des effets du réchauffement climatique. 2008; 247 p. Available at: http://www.developpement-durable.gouv.fr/IMG/pdf/Rapport_complet_0907allegeV2_20-11-08.pdf

[12] Santé Canada. Santé et changements climatiques : évaluation des vulnérabilités et de la capacité d'adaptation au Canada. Ottawa: Santé Canada. 2008; 548 p.

[13] English PB, Sinclair AH, Ross Z, Anderson H, Boothe V, Davis C, *et al.* Environmental health indicators of climate change for the United States: Findings from the State Environmental Health Indicator Collaborative. Environ Health Perspect. 2009; 117(11):1673-81.

[14] Spickett J, Brown H, Katscherian D. Department of Health. Health impacts of climate change: Adaptation strategies for Western Australia. Perth: Environmental Health Directorate. 2008; 75 p.

[15] Menne B, Bertollini R. Health and climate change: a call for action. BMJ. 2005;331(7528):1283-4.

[16] Thacker SB, Stroup DF. Public Health Surveillance. In: Brownson RC, Petitti DB, (dir.). Applied epidemiology Theory to practice. New York: Oxford University Press; 1988. p. 105-35.

[17] Medeiros H, Pascal M, Viso AC, Medina S. Workshop on public health surveillance and climate change. Saint Maurice: Institut de veille sanitaire; 2010. pp.1-38. Available at: http://opac.invs.sante.fr/index.php?lvl=notice_display&id=457

[18] Beaudeau P, Pascal M, Mouly D, Galey C, Thomas O. Health risk associated with drinking water in a context of climate change in France: a review of surveillance requirements. J Water Climate Change. 2011;2(4):230-45.

How to cite this article: Pascal M, Medina S, Viso AC, Beaudeau P. Quels impacts sanitaires du changement climatique et quels rôles pour la surveillance ? [What are the health impacts of climate change and what role does surveillance play?]. Bull Epidémiol Hebd. 2012;(12-13):146-8.

Winter mortality in a changing climate: will it go down?

Patrick L. Kinney (plk3@columbia.edu)[1], **Mathilde Pascal**[2], **Robert Vautard**[3], **Karine Laaidi**[2]

1/ Columbia University, Mailman School of Public Health, New York, USA
2/ Institut de Veille Sanitaire, Saint-Maurice, France
3/ Laboratoire des Sciences du Climat et de l'Environnement, Paris, France

Abstract

It is well known that death rates in temperate regions of the northern hemisphere are higher in winter than during other parts of the year, and further, that extreme heat during summer can lead to spikes in mortality. Together, these seasonal phenomena result in a U shaped relationship between daily mortality and temperatures. The shape and position of the U varies by location, and especially by average temperatures, showing that cities adapt to their local climate. In cooler cities, the increase in deaths at low temperatures is relatively shallow, and the increase in deaths with high temperatures relatively steep. By contrast, in warmer cities, the cold function is relatively steep and the hot function relatively shallow. With continued global warming due to anthropogenic greenhouse gas emissions virtually certain over coming decades, it is important to consider how the health response might change. In particular, we consider the question of whether winter mortality might diminish as temperatures rise in the future. Answering this question will have very important implications for public health adaptation planning. Somewhat surprisingly, based on the available literature, we conclude that it is unlikely that winter mortality would substantially diminish as temperatures rise.

Keywords

Winter, temperature, cold spell, mortality, climate change, projections

Introduction

It has long been observed that death rates in temperate regions of the northern hemisphere are higher in winter months than during other parts of the year, particularly for cardiovascular and respiratory conditions. However, huge disparities have been observed between countries, and the most affected are not the coldest. For instance, in Europe, between 1988 and 1997, the highest winter mortality rates were observed in Portugal, in Spain and in Ireland [1].

It is also well known that extreme heat episodes during summer can lead to spikes in mortality [2;3]. Together, these seasonal phenomena result in a U shaped relationship between daily mortality and temperatures in most locations [2;4-8], with increases in death rates observed at both low and high temperatures, and with a "comfort zone" in between.

Interestingly, the shape and placement of the typical U shaped temperature/mortality curve differs by latitude [9]. This is illustrated schematically in Figure 1. In cooler cities, the comfort zone is shifted to the left (i.e., lower temperatures); the increase in deaths at low temperatures relatively shallow and the increase in deaths with high temperatures relatively steep. By contrast, in warmer cities, the comfort zone is shifted to the right (i.e., higher temperatures); the cold function relatively steep and the hot function relatively shallow.

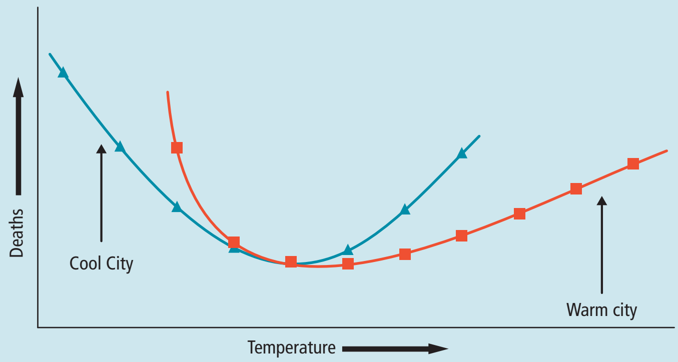
The geographic differences in the U shaped temperature/mortality function indicate that cities have adapted to their local climate. But how might this change in the future?

With continued global warming due to anthropogenic greenhouse gas emissions virtually certain over coming decades, to what extent will cities adapt to the new, warmer climate, and how much time will this adaptation take? Will winter mortality diminish as temperatures rise? Because winter-season deaths outnumber those in other seasons, answering these questions will have very important implications for public health adaptation planning.

Global average temperatures have been rising for the past century, and the warming trend has accelerated in recent decades [10]. Climate models consistently predict further warming of about 0.2°C/decade over the next few decades, with significant regional variations. In Europe, lower temperatures are projected to increase at a higher rate in winter than warmer temperatures, therefore tightening the distribution in winter in the future climate [11]. However, the occurrence of extremely cold spells cannot be excluded. Although it remained a moderately cold winter among the past 60 years, the winter of 2010 in Europe caused significant perturbations in several economical sectors (the health impacts has not been quantified yet) and is a good example of the occurrence of cold events mitigated by long-term climate warming [12].

Unfortunately, while much has been written about heat-related health impacts in the context of climate change [2;3], relatively less scholarly attention has been devoted to the larger and in some ways more important issue of possible changing winter health impacts.

Figure 1 **Schematization of the relationship between temperature and mortality**



Few studies to-date have addressed potential future impacts of warming winter temperatures on mortality [13-15], and these generally have concluded that there will be a decrease in winter mortality. The Intergovernmental Panel on Climate Change (IPCC) stated that climate change may "bring some benefits, such as fewer deaths from cold exposure" [16]. In Europe, it was even estimated that reductions in winter mortality could compensate for the increase in summer mortality with climate warming [17]. Although these conclusions seem quite intuitive, they are based on the assumption that the U shape relation between temperature and mortality that has been observed historically in a given region will not change in the future and thus can be used directly to estimate future mortality under warmer temperatures in that region.

We reviewed the historical literature to gain insights into the mechanisms underlying elevated winter mortality and the importance of seasonal factors vs. temperature per-se., in order to verify if this assumption could be considered valid. To gather relevant literature, we scanned publications on temperature-related mortality, identifying papers that included winter or cold effects. Reference lists were examined to identify additional papers from the older literature. In this way, a total 53 publications were identified and reviewed. We highlight key knowledge gaps that still remain.

Winter season *vs.* cold: what is killing the most?

Mortality is on average higher in winter than in summer in cities throughout the US and Europe [18]. In addition to overall winter season elevation in deaths, brief episodes of extreme cold during the winter season can increase mortality rates in the short run. Thus, we hypothesize that winter mortality elevation is comprised of two parts, one related to seasonal factors and another related directly to cold temperatures. The distinction may seem academic, but becomes important when one seeks to model future impacts of changing temperatures. A temperature-related health effect might be expected to change as exposures to temperature change. By contrast, a season-related health effect might not change with changing temperatures. But how can we distinguish the relative importance of these two components? The existing literature is a useful guide.

A large number of studies have examined and compared winter-season mortality elevation in regions with differing climates [1;9;19-27]. One very consistent finding across these studies is that the magnitude of winter season elevation in mortality is larger in regions that have milder winters. This observation is clearest in studies that analyze the ratio of winter season mortality to mortality in other seasons. In one such study, winter excess deaths from 1970-91, expressed as the percent above expected (defined as the mean of mortality observed in spring and autumn) for the months December through March, was twice as large in England and Wales (21%) as in Norway (11%) [28]. In another seasonal study of 14 European countries from 1988-97, winter excess mortality ranged from 10% in Finland to 28% in Portugal [1].

As a group, these studies show that regions that have acclimatized to warm climate can exhibit up to 2-3 fold larger winter season increase in mortality than those regions that have acclimated to colder temperatures. This would tend to imply that, in the future under a warmer climate, winter season mortality might be expected to increase as more and more regions acclimatize to warmer temperatures.

When deaths are analyzed as a function of temperature rather than season, the increased winter impact on mortality in warm regions becomes even more apparent. For example, McMichael *et al*. [25] reported a mortality increase of 4% per °C drop in cool-season temperatures in Bangkok, Thailand, whereas mortality increased just 0.4% per °C drop in cool season temperatures in Ljubljana, Slovenia. The mean annual temperatures in Bangkok and Ljubljana were 29 and 11°C, respectively. This strong gradient across cities in apparent temperature effect is likely because the range of winter temperatures is so much smaller in warm regions like Bangkok (only 3°C difference between 5th percentile and the annual mean). If the winter season effect is misattributed as a temperature effect, it may look very large indeed.

Making a correct distinction between seasonal factors and cold temperatures is also essential when it comes to the statistical modeling. The time-series approach has the potential to separately identify and quantify the winter seasonal effect from more short-term cold episode impacts, and has largely been used by recent studies to quantify mortality effects of temperature in both winter and summer. To date, however, we assumed that few studies have adequately modeled the season and the temperatures. The seasonal factor is usually treated as a confounder to control (but not quantify), whereas the daily temperature effect is directly modeled. Unfortunately, temperature is often modeled using long-period moving averages of 2-4 weeks, which may capture some of the winter seasonal effect, even when a smooth time function is simultaneously used to capture the season in the model [19;20;25]. Thus the results to date are quite difficult to interpret as clear temperature effects as distinct from seasonal phenomena.

Those studies which have controlled more effectively for seasonality and focused attention on short-term cold impacts have generally reported relatively modest cold effects [26;29;30]. While it is possible that this is because the cold effect operates over longer time-scales than a few days, it may also be that the cold effect is in fact rather small, and is accurately estimated once season is fully controlled. When studying those effects for which a long lag is assumed (3 weeks or more), it is more difficult to make a clear distinction between a temperature and a seasonal effect.

Making sense of all of these statistical associations would be easier if there were a good mechanistic understanding of winter season and/or cold temperature effects. In fact there has been considerable discussion of mechanisms in the literature. There are two competing theories. One suggests that cold temperatures have direct impacts on cardiovascular risk *via* blood thickening and increases in clotting factors, leading to thrombosis [13;31], and further that cold temperatures associated to dry air increase infectivity of organisms like influenza virus. Under this theory, warmer temperatures would be expected to reduce risk. It is interesting to note that in the UK and in Germany, improving the housing and the heating conditions were associated with a decrease in winter mortality [32] and an improvement of self-reported health [33;34]. However, although fuel poverty and poor isolation is a key matter, it is limited to a reduced fraction of the population. In the highly developed regions like the US and Europe, direct exposures to very cold temperatures are rare. Therefore we think that this theory cannot explain the totality of the winter excess mortality.

The other emerging theory is that infectious diseases, especially respiratory infections are elevated in winter for many reasons, and these lead to inflammation and increased cardiovascular risk [35;36]. There is no question that respiratory infections are elevated in winter – influenza being the most striking and significant example [35]. Why this is so remains unclear, but may relate to factors such as time spent indoors, holidays and school-related activities, low humidity, etc. It is difficult to foresee how ambient temperature would directly influence these parameters.

The impacts of cold spells

Despite a growing literature on the temperature-mortality relationship, little has been published on the mortality and morbidity impacts of specific cold spells. One early study documented increased myocardial infarction incidence in the 48 hours following sudden drops in temperature in Dallas, Texas [37]. In the US, a significant increase in mortality is associated with a temperature below the 1st percentile of the temperature distribution [27]. In addition to the temperature risks, cold spells may be associated with storms, snow and ice. An increase of CO poisoning have been observed during or immediately after cold episodes [38], while ice is consistently associated to an increase in injuries [39]. In January 1985, a cold spell was associated with around 13% excess mortality in France, with an observed increase in all causes of mortality, and especially in cardiovascular causes [40;41]. In January 2009, a significant increase in the mortality of people older than 95 years old was observed and may be partly explained by cold, but also by seasonal infections [42]. But the studies are descriptive, and do not provide clear quantitative information about the role of the cold temperatures compared to infectious diseases, nor about the main risk factors. Indeed, apart from the results of the Eurowinter study [23] which underlines the importance of adopting simple appropriate behaviour and clothing during cold spell, the lack of information limits our capacity to propose detailed intervention strategies, as can exist for heat waves.

Vulnerability of the population

In the last decades, vulnerability to direct health effects of cold temperatures is likely to have decreased due to an improvement in housing, heating devices and clothing. However, the ageing of the population may increase the vulnerability in the future years. As discussed above, the capacity to limit cold exposure is deeply linked with the capacity to pay for comfortable heating conditions. Although mechanisms exist to provide access to energy during winter months, the degradation of the socio-economic conditions may certainly result in an increase vulnerability to cold.

Regarding vulnerability to winter season effects, few data exist on changes over time. One US study looked at trends in the winter to summer mortality ratio from the 1930s to 1990s [43]. There was a drop in the ratio in mid century but then a rise from 1970 onward. The authors speculated that the latter rise might be due to decreasing heat-related deaths in summer as air conditioning prevalence increased.

We might also speculate that the observed rise in winter season mortality could be due to a gradual shift towards a warmer climate regime. An additional reason for an increase in vulnerability might be the acclimatization to warmer winters, reducing the adaptive capacity during cold episodes, whether this be by virtue of a reduction in their physiological adaptation to the cold or of a slight change in their behaviour patterns.

Conclusions: climate change and winter season mortality, what can we expect?

Based on our review of the literature, we think that it is not relevant to consider that the temperature-mortality response could be simply transposed in a context of climate change, allowing concluding that winter mortality will significantly decrease. If in fact the U function were to stay constant, and temperatures shifted to the right, then mortality in winter would drop and mortality in summer would go up. However, as noted above, the assumption of constant-in-time functional form is poorly supported by the cross-sectional evidence from different cities around Europe and the US which shows that, as you move to warmer climates, the shape of the left hand U becomes steeper, and the comfort zone shifts to the right. Based on this evidence, we assume that in a warmer future world, winter season mortality could still be at least as apparent as before, but could occur across a narrower, and warmer, range of ambient temperatures.

Therefore, based on our review, we argue that it is unlikely that warming winters due to climate change would result in substantially lower winter-season mortality in the US and Europe. In addition, we consider it likely that cold spells would still occur, and the associated health risk might remain significant. The interaction of three main risk factors, season – cold – infectious diseases, does not permit clear attribution of impacts to cold alone. Similarly to what has been done for heat waves, there is a need for epidemiological investigations of cold spells, to better quantify the health risks, identify the vulnerable population and defined appropriate preventions. There is also a need to better characterize exposure to cold, and to statistically differentiate temperature, seasons, and other confounding factors. This will require innovative study designs of the temperature – mortality relationship.

References

[1] Healy JD. Excess winter mortality in Europe: a cross country analysis identifying key risk factors. J Epidemiol Community Health. 2003;57(10):784-9.

[2] Basu R, Samet JM. Relation between elevated ambient temperature and mortality: a review of the epidemiologic evidence. Epidemiol Rev. 2002;24(2):190-202.

[3] Basu R. High ambient temperature and mortality: a review of epidemiologic studies from 2001 to 2008. Environ Health. 2009;(16)8:40.

[4] Ballester F, Corella D, Perez-Hoyos S, Saez M, Hervas A. Mortality as a function of temperature. A study in Valencia, Spain, 1991-1993. Int J Epidemiol. 1997;26(3):551-61.

[5] Hajat S, Kovats RS, Atkinson RW, Haines A. Impact of hot temperature on death in London: a time series approach. J Epidemiol Community Health. 2002;56(5):367-72.

[6] Kunst AE, Looman CW, Mackenbach JP. Outdoor air temperature and mortality in The Netherlands: a time-series analysis. Am J Epidemiol. 1993;137(3):331-41.

[7] Laaidi M, Laaidi K, Besancenot JP. Temperature-related mortality in France, a comparison between regions with different climates from the perspective of global warming. Int J Biometeorol. 2006;51(2):145-53.

[8] Pattenden S, Nikiforov B, Armstrong BG. Mortality and temperature in Sofia and London. J Epidemiol Community Health. 2003;57(8):628-33.

[9] Curriero FC, Heiner KS, Samet JM, Zeger SL, Strug L, Patz J. Temperature and mortality in 11 cities of the eastern United States. Am J Epidemiol. 2002;155(1):80-7.

[10] Solomon SD, Quin D, Manning M, Chen Z, Marquis M, Averyt KB, *et al.* Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, 2007. Cambridge, United Kingdom and New York, NY, USA: Cambridge University Press; 2007.

[11] Christensen JH, Hewitson B, Busuioc A, Chen A, Gao X, Held I, *et al.* Regional climate projections. In: Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change [Solomon, S., D. Qin, M. Manning, Z. Chen, M. Marquis, K.B. Averyt, M. Tignor and H.L. Miller (eds.)]. Cambridge, United Kingdom and New York, NY, USA: Cambridge University Press; 2007.

[12] Cattiaux J, Vautard R, Cassou C, Yiou P, Masson-Delmotte V, Codron F. Winter 2010 in Europe: a cold extreme in a warming climate. Geophysical Research Letter. 2010;37.

[13] Keatinge WR. Winter mortality and its causes. Int J Circumpolar Health. 2002;61(4):292-9.

[14] Langford IH, Bentham G. The potential effects of climate change on winter mortality in England and Wales. Int J Biometeorol. 1995;38(3):141-7.

[15] Martens WJ. Climate change, thermal stress and mortality changes. Soc Sci Med. 1998; 46(3):331-44.

[16] Parry ML, Canziani OF, Palutikof JP, Hanson CE. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. IPCC: United Kingdom and New York, NY, USA; 2007.

[17] Ciscar JC, ed. Climate change impacts in Europe. Final report of the PESETA Research Project. 2009 Nov. Available at: http://ipts.jrc.ec.europa.eu/publications/pub.cfm?id=2879

[18] Davis RE, Knappenberger PC, Novicoff WM, Michaels PJ. Decadal changes in summer mortality in U.S. cities. Int J Biometeorol. 2003;47(3):166-75.

[19] Analitis A, Katsouyanni K, Biggeri A, Baccini M, Forsberg B, Bisanti L, *et al.* Effects of cold weather on mortality: results from 15 European cities within the PHEWE project. Am J Epidemiol. 2008;168(12):1397-408.

[20] Anderson BG, Bell ML. Weather-related mortality: how heat, cold, and heat waves affect mortality in the United States. Epidemiology. 2009;20(2):205-13.

[21] Anderson TW, le Riche WH. Cold weather and myocardial infarction. Lancet. 1970;1(7641):291-6.

[22] Barnett AG, Dobson AJ, McElduff P, Salomaa V, Kuulasmaa K, Sans S. Cold periods and coronary events: an analysis of populations worldwide. J Epidemiol Community Health. 2005;59(7):551-7.

[23] Eurowinter G. Cold exposure and winter mortality from ischaemic heart disease, cerebrovascular disease, respiratory disease, and all causes in warm and cold regions of Europe. The Eurowinter Group. Lancet. 1997;349(9062):1341-6.

[24] Mckee CM. Deaths in winter: can Britain learn from Europe? Eur J Epidemiol. 1989;5(2):178-82.

[25] McMichael AJ, Wilkinson P, Kovats RS, Pattenden S, Hajat S, Armstrong B, *et al.* International study of temperature, heat and urban mortality: the 'ISOTHURM' project. Int J Epidemiol. 2008;37(5):1121-31.

[26] Medina-Ramon M, Schwartz J. Temperature, temperature extremes, and mortality: A study of acclimatization and effect modification in 50 United States Cities. Occup Environ Med. 2007.

[27] Medina-Ramon M, Zanobetti A, Cavanagh DP, Schwartz J. Extreme temperatures and mortality: Assessing effect modification by personal characteristics and specific cause of death in a multi-city case-only analysis. Environ Health Perspect. 2006;114(9):1331-6.

[28] Laake K, Sverre JM. Winter excess mortality: a comparison between Norway and England plus Wales. Age Ageing. 1996;25(5):343-8.

[29] Doyon B, Bélanger D, Gosselin P. The potential impact of climate change on annual and seasonal mortality for three cities in Québec, Canada. Int J Health Geogr. 2008;7:23.

[30] Kloner R, Poole WK, Perritt RL. When throughout the year is coronary death most likely to occur? A 12-year population-based analysis of more than 220 000 cases. Circulation. 1999;100(15):1630-4.

[31] Donaldson GC, Keatinge WR. Early increases in ischaemic heart disease mortality dissociated from and later changes associated with respiratory mortality after cold weather in south east England. J Epidemiol Community Health. 1997;51(6):643-8.

[32] WHO Regional Office for Europe. Housing, energy and thermal comfort. A review of 10 countries within the WHO European Region. Copenhagen, Denmark: WHO Regional Office for Europe; 2007.

[33] Braubach M, Jacobs D, Ormandy D. Environmental burden of disease associated with inadequate housing. Copenhagen, Denmark: WHO Regional Office for Europe; 2011.

[34] Braubach M, Heinen D, Dame J. Preliminary results of the WHO Frankfurt housing intervention project. Copenhagen, Denmark: WHO Europe; 2008.

[35] Reichert T, Simonsen L, Sharma A, Pardo S, Fedson DS, Miller M. Influenza and the winter increase in mortality in the United States, 1959-1999. Am J Epidemiol. 2004;160(5):492-502.

[36] Woodhouse PR, Khaw KT, Plummer M, Foley a, Meade TW. Seasonal variations of plasma fibrinogen and factor VII activity in the elderly: winter infections and death from cardiovascular disease. Lancet. 1994;343(8895):435-9.

[37] Teng H, Heyer H. The relationship between sudden changes in weather and the occurence of acute myocardial infarction. Am Heart J. 1955;49(1):9-20.

[38] Verrier A, Delaunay C, Coquet S, Théaudin K, Cabot C, Girard D, *et al.* Les intoxications au monoxyde de carbone survenues en France métropolitaine en 2007. Bull Epidémiol Hebd. 2010;(1):1-5.

[39] Morency P, Voyer C, Beaulne G, Goudreau S. Chutes extérieures en milieu urbain : impact du climat hivernal et variations géographiques. Montréal, Canada: Agence de la santé et des services sociaux de Montréal; 2010.

[40] Beaudeau P, Besancenot JP, Casério-Schönemann C, Cohen JC, Dejour-Salamanca D, Empereur-Bissonnet P, *et al.* Froid et santé. Éléments de synthèse bibliographique et perspectives. Rapport d'investigation. 2004. 48 p.

[41] ORS Île-de-France. Conséquences de la vague de froid de janvier 1985 sur la mortalité en Île-de-France. 1987.

[42] Fouillet A, Ilef D, Josseran L. Surveillance de la mortalité en France au cours de l'hiver 2008-2009, premiers éléments. Bull Epidémiol Hebd. 2009;(15):133-7.

[43] Seretakis D, Lagiou P, Lipworth L, Signorello LB, Rothman KJ, Trichopoulos D. Changing seasonality of mortality from coronary heart disease. Jama. 1997;278(12):1012-4.

How to cite this article: *Kinney PL, Pascal M, Vautard R, Laaidi K. La mortalité hivernale va-t-elle diminuer avec le changement climatique ? [Winter mortality in a changing climate: will it go down?].Bull Epidémiol Hebd; 2012. (12-13):148-51.*

Management of extreme weather events: the need for a planned epidemiological answer integrated in the organization of the health and social response

Philippe Pirard (p.pirard@invs.sante.fr)**, Mathilde Pascal, Yvon Motreff**

Institut de Veille Sanitaire, Saint-Maurice, France

Abstract

In the near future, it is likely that the frequency of extreme meteorological events will increase. Anticipating them requires the organization of crisis and consequence management. Epidemiology can help guide preventive and health actions, through identification of exposed populations, detection of health events, and quantification of the health impact.

The epidemiological surveillance of heat waves is a component of the national heat wave plan, and is closely associated with the surveillance of meteorological forecasts. Its objectives are to evaluate the health situation, to alert, and to recommend preventive measures if needed. It focuses on a small number of health indicators that can be followed in near-real time, based on the data from networks of emergency hospital services (OSCOUR®) and emergency medical visits at home (SOS Médecins), as well as on registered fatalities. Additional epidemiological and sociological studies are needed to identify new kinds of vulnerabilities, and the adaptation measures needed to ensure the continued efficiency of preventive actions in the future.

The variety of possible scenarios and consequences of extreme weather events (storms, floods…) calls for reactive, specific surveillance, which can be rapidly reinforced for a given health effect or a given population. A global and representative assessment of the health impact necessitates both the use of data on health consumption (OSCOUR®, health insurance…) and data from cross-sectional or cohort studies to collect precise information, and to monitor the trends of health events at the individual level. To do so, epidemiologists must be involved in the organization of crisis and consequence management right from the planning stage.

In all cases, the necessary rigor and optimization needed should not be an obstacle to flexibility and reflexivity in surveillance systems, so that these latter can adapt rapidly to an evolving situation, and be improved through subsequent feedback.

Key words

Climate change, meteorological extreme events, epidemiology, management

Introduction

Extreme meteorological events may concern temperature (heat waves, severe cold spells), precipitation (heavy rain, floods and episodes of drought) and localized phenomenon like storms and cyclones. Mweteorological conditions may also encourage forest fires. It is probable that climate change will translate into an increase in the frequency and the intensity of some of these events in France [1;2].

These extreme events may have important human, economic and social impacts. The capacity to anticipate them and predict their consequences will be a key element in adaptation to climate change. To reduce the vulnerability of our society to these events, this anticipation must be widespread and must focus on the implementation of sustainable action, for example working on urban planning, on designing habitations, adaptation of crop agriculture etc. At the same time, the response to a crisis and the medium and long term management of its consequences must be organized, especially to reduce the health effects. Epidemiological tools implemented as a result of an extreme meteorological event provide information which helps orientate this organization. Effectively their objective is to:

- Identify a health phenomenon at an early stage and issue an alert;
- Quantify the event's impact on health;
- Identify and characterize exposed and most-at-risk populations;
- And in this way, help direct and evaluate preventive and health care actions arising from these unusual events.

Epidemiological surveillance is therefore organized as soon as the event occurs and may be continued after the event finishes, given its consequences, in order to primarily help action. Its principal characteristic is reactivity. It must adapt to the specificities of each event.

This surveillance may be accompanied by epidemiological studies to provide an in-depth analysis of the health effects, their duration, the mechanisms leading to the onset of these effects and contributing factors. These studies are necessary to identify the vulnerabilities of different populations as well as the specificities of health care. They also contribute to the analysis of the short- and long-term collective health impact, as well as to the evaluation of the efficacy of the measures and policies adopted. The time needed to complete these studies means that they will continue after the initial alert and the immediate response end.

The aim of this article is to present the place and role of epidemiological response in the management of health and social impacts arising from extreme meteorological events. In order to do this, two examples are investigated: a) heat waves and b) floods and storms.

Heat waves

Public health context and issues

The heat wave of 2003 highlighted a health crisis primarily in emergency services, in the health care of the elderly, and in the management of fatalities in France. Since then many epidemiological studies have been carried out. These have led to a greater understanding of vulnerable populations, the mortality-morbidity dynamics during heat waves, and possible preventive actions [3-8]. This knowledge has been translated into action by the implementation of the National Heat wave Plan (NHP), which aims to prevent and fight against health consequences of a heat wave. During an alert, the NHP is used to activate some, if not all, of the necessary measures for managing such an event.

Objectives and principles of an epidemiological surveillance system

Alerts focus on meteorological forecasts, in order to identify the days when a large excess mortality may be expected [9]. This system is original in the field of meteorological vigilance as the meteorological thresholds have been defined on the basis of an analysis of the relationship between temperature and mortality over the last 30 years. Every day, the alert is issued by Météo-France (the French National Meteorological Service) and possibly discussed with the French Institute for Public Health Surveillance (Institut de Veille Sanitaire -InVS). Furthermore, heat waves may simultaneously affect several dozens of districts. This results in the need to process a great deal of information in a short time.

In this context, the objective of health surveillance is not to issue an alert, but rather to verify that the health situation is under control, in order to adapt management measures if necessary, to end an alert or on the contrary to continue it. This surveillance focuses on a small number of health indicators that can be followed in near-real time: visits to Emergency units by subjects over 75 years or for heat-related reasons, SOS Doctor emergency calls, total registered fatalities provided by INSEE (the French National Institute of Statistics and Economics Studies), especially by age group. These indicators were chosen according to their reactivity to heat and the quality of data available. They are collected by InVS regional offices (Cire) for sentinel hospitals, and analyzed with predefined statistical methods (historical limits, control charts), in order to identify - for a given period - a significant modification in the magnitude of the indicator analyzed. The statistical analysis leads to a "statistical alarm" which may be linked to the quality of the data and to a real health-related event. The epidemiological assessment carried out by the Cire is essential therefore to transform this alarm into a valid health signal [10]. This latter is then transmitted to different actors within the system (Météo-France, InVS, The Department for Public Health (DPH), Regional Health Agencies (RHA)) as an event management tool.

It is an example of a very formalized response to an extreme event, wherein health data have a very defined role. Although this formalization is made possible by the corpus of available knowledge on heat wave effects and by the constraints imposed on the alert system, it must not hide the importance of taking a broad view of surveillance and moreover the importance of vigilance. This is necessary to identify unexpected signals (for example, unexplained fatalities of relatively young workers or fatalities due to heat stroke within different companies etc.) , outside of procedure, but which could be associated with heat waves and necessitate immediate investigation. There is a strong collaboration therefore between the syndromic surveillance system, local and national early-warning systems, and all the InVS partners.

At the end of the season, an initial rapid assessment of the effects of a heat wave is possible by estimating the observed mortality with respect to the reference mortality, in order to identify events and vulnerabilities which may need more in-depth studies [10].

Finally, the evolution of temperature in the context of climate change raises the question of the adaptation of populations to more frequent and intense - perhaps even more humid - heat waves in the coming years. Physiological adaptation seems to be limited. Furthermore both increasing urbanization (the phenomenon of heat islands) and ageing of the population strongly suggest greater vulnerability in the future. Technological adaptation is possible (air conditioning techniques, urban planning aiming to reduce urban heat islands, strengthening of the NHP), but may, at any moment, be challenged by economic and sociological considerations.

In this context the NHP will have to be flexible and reactive. Epidemiological studies must not be the only focus for future changes to the NHP. Sociological, urbanism and other studies will also play their part in analyzing the mechanisms which take place when a heat wave occurs and the efficacy of the actions put in place: improved understanding of the mortality-morbidity dynamic, analysis of the efficacy of proposed measures, emergence of new kinds of vulnerability (age-isolation relationship, socio-economic data, urbanism).

Storms and floods

Public health context

Unlike heat waves, these events are characterized by their physical violence. They create visible and direct impacts on the population: violent death, destruction of houses or work equipment. They often cause severe shock for the population due to an instant break in the environmental and social space. The magnitude of this break is greater than the community's capacity to deal with it. Storms and floods are also characterized by a great variability of possible scenarios and means of exposure to health risks. Their health impacts are therefore much more wide-ranging than the immediate fatalities and physical traumatisms.

Environmental disruptions, which are secondary to the catastrophe (for example, degraded housing conditions, etc.), are also likely to aggravate the health impact [11-13]. For example, carbon monoxide (CO) poisoning epidemics have been observed following floods and episodes of violent gales (Klaus) [12;13]. In certain cases, the extreme event may bring about an industrial catastrophe where toxic substances can be released [14].

Loss of human life and important material damage (homes, work equipment) have a psychological impact which may be severe [11;12;15]. Furthermore, the conditions in which affected people must reintegrate into society after a natural catastrophe add prolonged stress to that arising from the direct consequences of the catastrophe (loss of work, loss of home etc.) [11;12;15]. This impact of natural catastrophes on mental health, both in the short and long term, has been highlighted in France on several occasions (e.g. the floods in the Somme area in 1999 [15], in the Gard area in 2002 [16], and in the Bédarrides (Vaucluse) area 1992 [11]), and internationally (e.g. hurricane Katrina in the United States 2005 [17]). Finally, the individual's mental health and the collective socioeconomic consequences of a catastrophe may interact negatively. This lack of psychosocial well-being may notably translate into increased prevalence of drug dependence or violence. These are as much indicators of a collective lack of well-being as of an individual one. It is important to take these interactions into account in preventive actions and in the long term objectives of epidemiological surveillance measures in impacted communities [18], especially through targeting sub-groups of the population who are at greater risk socially.

Surveillance and epidemiological studies play an important role in identifying and quantifying all these health impacts in the short medium and long term, and accordingly, in guiding recommendations aimed at reducing them. These recommendations may help for the event in question, but may also be of help for future events.

Objectives and principles of the epidemiological response after a flood or a storm

In the immediate post-event phase, the first objectives of the epidemiologist are to identify the populations affected, to prioritize the acute and delayed effects to be monitored according to the nature, the place and the extent of the catastrophe as well as to issue an alert about the possible occurrence of unusual effects.

These objectives require a rapid synthesis of the available information regarding the event scenario (bibliography, information coming from public services as well as from immediate crisis management actors, information coming from the surveillance systems, list of at-risk establishments of collective care, cartography of the damage or the flooded zones, etc.) to evaluate the number of victims, of injured and exposed people, the observed effects, the material and agricultural damage etc. In this phase, all health resources are already being fully exploited and even overwhelmed. Surveillance systems must therefore be simple, time-limited, and must prioritize the events to be monitored, relying as much as possible on already existing systems. For example in France these existing systems are the permanent monitoring of Emergency services (Oscour®, SOS Médecins), of computerized reporting of fatalities at the communal level and the specific CO poisoning surveillance system. In parallel, the healthcare network (general practitioners and specialists) may create an alert network to signal the occurrence of unusual health-related events [12;19]. When healthcare systems are deployed in exceptional cases on the ground, basic medical data collection will have to be planned. It will be analysed centrally in near-real time. This is what happened for health staff who were part of the enhanced psychological care device implemented as a result of the storm Xynthia at the end of February 2010. Each member of staff was asked to fill out a quick epidemiological questionnaire which would help measure the activity of the implemented care structure. In this way, the Limousin-Poitou-Charentes Cire (InVS regional office) has been able to identify the populations using this care structure as well as vulnerable populations. It has also been able to show the evolution of the use of the structure and provide information about the evolution of the mental health impact, as much linked to the primordial event as linked to its medium-term consequences. This data helped adapt the care structure both by prolonging its existence beyond the month previously forecast and by justifying its end six months later. It also helped to identify the necessity of a supplementary local consultation centre in a commune which had not been included when the structure was first put in place [20].

Epidemiological surveillance must be flexible and reactive in order to adapt to event-specific scenarios and to implemented actions. Depending on the health and social context on the field, it must also be able to be adapted to the local available data or to be rapidly reinforced for a particular health-related effect or zone. An example of this is the Cire Sud which immediately upon the announcement of the Var area flood in June 2010, worked with the Provence-Côte d'Azur Regional Emergencies Health Observatory to ensure that doctors in the three surrounding hospitals labeled emergency visits which they judged were related to the flood. Another example is the use of the opportunity of having computered free text systematic notifications from medical staff about reasons for using emergency services at the Mont-de-Marsan hospital located in a highly-forested district to analyse it. The analysis highlighted a large number of visits associated with the use of chainsaws in the month following storm Klaus (29 visits linked to chainsaw accidents as opposed to 6 during the same period the previous year) [22].

Surveillance systems have to focus on their sensitivity even if detected events need to be verified afterwards. In this case epidemiological investigations will be carried out on the field using standardized criteria to validate the reality of a public health alert. In this way, the investigations carried out in the context of the CO poisoning surveillance system following Klaus - where 109 episodes of CO poisoning were recorded - showed that the majority of these cases were linked to the use of generators as alternative sources of electricity [13].

In the medium term, epidemiological studies must specify the nature of the impact, evaluate its size, and monitor associated spatial and temporal trends.

As in the case of the Gard flood in 2002 [16], these studies may use medico-economical data (data on health insurance reimbursement and hospital discharge, diagnostic related groups), to monitor impacts. They can also use pre-existing information systems - whose use was not initially planned - to monitor the state of health of populations (e.g. recorded misdemeanors) or information sources which are more adapted for certain marginalized populations (e.g. local association social support informants). These studies may also take the form of cross-sectional surveys or cohort surveys which help ensure accurate data collection and the monitoring health-related events (e.g. mental health) at the individual level (e.g. floods in the Somme [15] and Bédarrides [11]). These studies are more effective when started very quickly after the event occurs, before populations disperse and are lost to follow-up, as exposure measurements are still possible and less associated with memory recall bias [23].

Past experience shows that epidemiological analysis of the impact of storms has often been partial and incomplete. But it is the combination of information provided by these various epidemiological tools which ensure a representative and global evaluation of the health impact of a storm. The InVS's "Program for the preparation of the epidemiological response to industrial accidents and catastrophes" (PERAIC) is to integrate these different tools and to prepare this global epidemiological response beforehand [24]. To achieve this goal, crisis management actors must identify epidemiologists and what they can bring. The epidemiologists must also convince decision makers and authorities to integrate epidemiological surveillance in contingency plans for the management of these extreme meteorological events as well as to allow them to participate to the subsequent feedbacks on the events. The preparation of the epidemiological surveillance is made with the participation of local health professionals (medico-psychological emergency units, emergency medical services, firemen, general doctors and hospitals). The sources of data and data collection methods, the routine analyses and indicators produced, the alert procedures (alert thresholds) and the epidemiological investigation protocols are defined with the help of these various local health professionals. The organization and interaction between epidemiologists and local actors must be integrated in the disaster response plans. Epidemiologists must be integrated into the crisis management centers. For example they can integrate in France the RHA "regional support units" which work in close and permanent collaboration with the prefecture in case of a crisis with health issues. Similarly, the French State must provide itself with the technical, organizational and logistical means to carry out individual epidemiological studies which are immediately necessary very after the occurrence of a storm (implementation of scientific committees and monitoring, choosing implementing criteria operational methods).

Conclusion

Apart from very short term situations, extreme climate events remain unpredictable in terms of the time and place of their occurrence. Nevertheless, the response to these events necessitates careful planning. Epidemiological surveillance must form part of this planning - at regional and national levels - as it is of major public health importance by bringing essential information to crisis management. In response to these events, the intervention of epidemiologists immediately upon the occurrence of the meteorological alert is justified, as health-related events help to qualify the gravity of the impact. In this way they can also become one of the alert criteria. Epidemiological preparedness to floods and storms and epidemiological preparedness to heat waves respond to different issues which require different modes of structuring. In the case of heat waves, a strong formalization of the integration of epidemiological surveillance results in the management plans is encouraged by the decision makers. They do not want to relive the 2003 heat wave whose magnitude surprised and exceeded health care emergency responsive systems at national level. This formalization is also possible as the panel data for expected effects is *a priori* limited. Regarding floods and storms, event scenarios are more varied, as much for the intensity of these phenomena as for their possible effects. Furthermore, the management actors with whom epidemiologists must interact are both more numerous and more focused on protecting populations. These characteristics require above all great flexibility and adaptability of the epidemiologists as well as of proposed surveillance systems.

But finally, matching the needs of rigor and optimization with elements of flexibility and reflexivity (the capacity of regular self-analysis and self-evaluation) is an issue for post-meteorological disaster epidemiological surveillance, if we want it to be able to adapt immediately to changes in a given situation, and to improve from future feedback.

Références

[1] IPCC. Intergovernmental Panel on Climate Change Special Report on Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation. Summary for Policymakers. Cambridge, United Kingdom and New York, NY, USA: Cambridge University Press; 2011. 19 p. Available at : http://ipcc-wg2.gov/SREX/

[2] Solomon SD, Quin D, Manning M, Chen Z, Marquis M, Averyt KB, *et al*. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, 2007. Cambridge, United Kingdom and New York, NY, USA: Cambridge University Press; 2007. 996 p.

[3] Fouillet A, Rey G, Wagner V, Laaidi K, Empereur-Bissonnet P, Le Tertre A, *et al*. Has the impact of heat waves on mortality changed in France since the European heat wave of summer 2003? A study of the 2006 heat wave. Int J Epidemiol. 2008 37(2):309-7.

[4] Le Tertre A, Lefranc A, Eilstein D, Declercq C, Medina S, Blanchard M, *et al*. Impact of the 2003 heatwave on all-cause mortality in 9 French cities. Epidemiology. 2006;17(1):75-9.

[5] Ledrans M. Impact sanitaire de la vague de chaleur de l'été 2003 : synthèse des études disponibles en août 2005. Bull Epidémiol Hebd. 2006;(19-20):130-7.

[6] Le Tertre A, Laaidi K, Josseran L, Wagner V, Jougla E, Empereur-Bissonnet P, *et al*. Première estimation de l'impact de la vague de chaleur sur la mortalité durant l'été 2006, France. Bull Epidémiol Hebd. 2007;(22-23):190-2.

[7] Rey G, Fouillet A, Bessemoulin P, Frayssinet P, Dufour A, Jougla E, *et al*. Heat exposure and socio-economic vulnerability as synergistic factors in heat-wave-related mortality. Eur J Epidemiol. 2009;24(9):495-502.

[8] Vandentorren S, Bretin P, Zeghnoun A, Mandereau-Bruno L, Croisier A, Cochet C, *et al*. August 2003 heat wave in France: risk factors for death of elderly people living at home. Eur J Public Health. 2006;16(6):583-91.

[9] Pascal M, Laaidi K, Ledrans M, Baffert E, Caserio-Schönemann C, Le Tertre A, *et al*. France's heat health watch warning system. Int J Biometeorol. 2006;50(3):144-53.

[10] Pascal M, Laaidi K, Ung A, Beaudeau P. Méthodes d'analyse de l'impact sanitaire des vagues de chaleur : suivi en temps réel, estimation a posteriori. Saint-Maurice: Institut de veille sanitaire; 2011. 48 p.

[11] Verger P, Rotily M, Hunault C, Brenot J, Baruffol E, Bard D. Assessment of exposure to a flood disaster in a mental-health study. J Expo Anal Environ Epidemiol. 2003;13(6):436-42.

[12] Verger P, Aulagnier M, Schwoebel V, Lang T. Démarches épidémiologiques après une catastrophe. Anticiper les catastrophes : enjeux de santé publique, connaissances, outils et méthodes. Paris: La Documentation Française; 2005. 265 p.

[13] Coquet S, Mansotte F, Cabot C, Ricoux C, Sauthier N, Motreff Y, *et al*. Phénomène climatique exceptionnel et intoxications au monoxyde de carbone : de la surveillance à l›action de sante publique, France, Sud-Ouest, janvier 2009. Bull Epidémiol Hebd. 2011;(45-46):467-71.

[14] Appel A. After Katrina: tracking the toxic flood. Nature. 2005;437(7058):462.

[15] Ligier K, Ganiayre F, Zielinski O, Ilef D, Trugeon A, Guillaumont C, *et al*. Health survey among flood victims in the Somme area. Rev Epidémiol Sante Publique. 2005;53(6):658-65.

[16] Six C, Mantey K, Franke F, Pascal L, Malfait P. Étude des conséquences psychologiques des inondations à partir des bases de données de l'Assurance maladie, département du Gard, septembre 2002. Saint-Maurice: Institut de veille sanitaire; 2008. 23 p. Available at : http://www.invs.sante.fr/publications/2008/inondation_gard/index.html

[17] Galea S, Brewin CR, Gruber M, Jones RT, King DW, King LA, *et al*. Exposure to hurricane-related stressors and mental illness after Hurricane Katrina. Arch Gen Psychiatry. 2007;64(12):1427-34.

[18] Yun K, Lurie N, Hyde PS. Moving mental health into the disaster-preparedness spotlight. N Engl J Med. 2010;363(13):1193-5.

[19] Tsouros AD, Efstrathiou PA. Mass gatherings and public health. The experience of the Athens 2004 Olympic Games. Geneva: WHO; 2007. 377 p.

[20] Raguenaud ME, Germonneau P, Pirard P, Motreff Y. Surveillance des conséquences psychologiques suite à la tempête Xynthia en Charente-Maritime en 2010. Saint-Maurice: Institut de veille sanitaire; 2011. 29 p. Available at : http://www.invs.sante.fr/Publications-et-outils/Rapports-et-syntheses/Environnement-et-sante/2011/Surveillance-des-consequences-psychologiques-suite-a-la-tempete-Xynthia-en-Charente-Maritime-en-2010

[21] Cire Sud. Bulletin de veille sanitaire Paca-Corse n°3, juillet 2011. 8 p. Available at : http://www.invs.sante.fr/Publications-et-outils/Bulletin-de-veille-sanitaire/Tous-les-numeros/Sud/Bulletin-de-veille-sanitaire-Paca-Corse.-n-3-juillet-2011

[22] Verrier A, Motreff Y, Pirard P. Encadré 1. Surveillance épidémiologique activée lors de la tempête Klaus. In: Astagneau P, Ancelle T (dir). Surveillance épidémiologique. Paris: Lavoisier; 2011. p 233.

[23] Lang T, Schwoebel V, Diene E, Bauvin E, Garrigue E, Lapierre-Duval K, *et al*. Assessing post-disaster consequences for health at the population level: experience from the AZF factory explosion in Toulouse. J Epidemiol Community Health. 2007;61(2):103-7.

[24] Pirard P, Motreff Y, Schwoebel V, Ricoux C. Encadré. Préparation en réponse aux accidents industriels et catastrophes (Peraic). Bull Epidémiol Hebd. 2009;(35-36):386-7.

<u>How to cite this article</u>: Pirard P, Pascal M, Motreff Y. Gestion des événements climatologiques extrêmes : nécessité d'une réponse épidémiologique intégrée et planifiée dans l'organisation de la réponse sanitaire et sociale. [Management of extreme weather events: need for an integrated and planned epidemiological answer in the organization of health and social response]. Bull Epidémiol Hebd. 2012;(12-13):152-5.

Determinants of human infectious diseases in Europe: biodiversity and climate variability influences

Serge Morand (serge.morand@univ-montp2.fr)[1], **Agnès Waret-Szkuta**[2]

1/ Institut des Sciences de l'Evolution, CNRS, IRD, Université Montpellier 2, CC065, Montpellier, France ; CIRAD UR AGIRs, TA C-22/E, Montpellier, France
2/ CIRAD UR AGIRs, TA C-22/E, Montpellier, France ; ENVT, Clinique aviaire et porcine, Toulouse, France

Abstract

Infectious diseases' incidence has clearly increased during the last decades. The explanatory factors reported are generally those associated with ongoing global changes, including climate change, loss of biodiversity, and increased international trade. In this study, we analyze the potential explanatory factors of human infectious disease outbreaks across European countries (as defined by the WHO). For this purpose, a database including data about socio-economical, environmental and biodiversity related factors, as well as the main human infectious diseases reported was designed.

Over the period 1950 to 2010, 114 epidemic infectious diseases were identified in 36 countries. These data confirm the almost exponential increase in the number of infectious disease outbreaks in recent decades. The total number of diseases listed in any given European country seems to be correlated to its area size and biodiversity (species richness in birds and mammals). The total number of epidemic diseases is found to also depend on the population size and economic wealth (GDP) of the country, as well as on the prevailing temperature variability. The effect of the North Atlantic Oscillation (NAO) considered as an index of climate variability in Europe is tested for thirteen infectious diseases which can be analyzed over the last 60 years. The occurrence of 11 of these, including hantavirus hemorrhagic fevers, tularaemia, Q fever, trichinosis and bacterial or viral gastrointestinal diseases, is found to be associated with monthly variations of NAO.

This study highlights that both biodiversity change and climate variability should be taken into account when building epidemio-surveillance early warning systems.

Keywords

Europe, infectious diseases, epidemic, biodiversity, climate variability, NAO index

Introduction

Infectious diseases' incidence has clearly increased during the last decades [1]. The explanatory factors reported are generally those associated with ongoing global changes, including climate change, loss of biodiversity and increased international trade. Nevertheless, it is difficult to demonstrate a direct impact of climate change on infectious diseases because of non-linear complex interactions between climate and biodiversity, pathogens, disease vectors and hosts [2]. Climate change is assumed to especially impact infectious vector-borne diseases [1;3], but a reduction in the biodiversity at the local level may also lead to an increase in the prevalence of certain diseases, as has been seen for Lyme disease and West Nile fever for example [4].

The majority of emerging infectious diseases seem to be localized in higher latitudes and in developed countries (North America, Europe and Japan) [1]. However, research investigating the explanatory factors for the variety (total number) of endemic diseases paints a very different picture. Their diversity seems to be greater in the tropical zones where bird and animal biodiversity is greatest [5;6].

The consequences of climate change in Europe have been the object of numerous syntheses [7] and several studies have been able to effectively demonstrate an effect of climate change on infectious diseases, as in the case of bluetongue [8]. Nevertheless, few studies have investigated the impact of climate change on infectious diseases on a comparative basis [9], and even fewer have explored the links between climate variability and epidemics in Europe [10;11].

The apparent contradictions between studies conducted at the worldwide scale on the geographic localizations and determinants of endemic and epidemic human infectious diseases, as well as the lack of a European-centered focus, led us to carry out an analysis of potential explanatory factors for human infectious disease epidemics at the European level. In order to do so, a database including data about socio-economical, environmental and biodiversity-related factors, as well as the main human infectious diseases epidemics reported per country, was designed. This enabled us to statistically test the influence of potential explanatory factors for these epidemics (according to WHO definitions: significant increases in the number of cases of the disease (or number of outbreaks) and including climate variability.

Methods

Information about infectious disease epidemics is provided by GIDEON (Global Infectious Diseases and Epidemiology Network[1]). This database, which provides information on the presence and occurrence of possible epidemics of human infectious diseases for each country, has regularly been used in comparative studies [5;6]. It was completed by adding socioeconomic, demographic and environmental data provided by FAO and the World Bank: demography, GDP, forested surface area, average temperatures and rainfall as well as annual variability of these latter two factors. Data for birds and mammals are also included (supplied by Bird Life International[2] and the International Union for Conservation of Nature respectively[3]).

Over the period 1950 to 2010, 114 epidemic infectious diseases were identified in 36 countries.

The impact of climate variability on epidemics is analyzed using the *North Atlantic Oscillation* (NAO) as this index is more pertinent to Europe than ENSO (*El Niño Southern Index*). The positive and negative phases of the NAO reflect the temperature and rainfall patterns for Europe. Data for monthly variations of this index come from NOAA[4] (the *National Weather Service of the National Oceanic and Atmospheric Administration*), and are incorporated into logistic regression models with the year being a confounding variable. The GIDEON database was set up in 1994 and some of the information contained in it dates back to the beginning of the 20th century.

As a second step, thirteen infectious diseases were selected on the basis that their detection could be traced back at least to the end of the 1950s. This was done to obtain a sufficiently long statistical series from 1950 to 2009. The choice of 1950 as a start point is also influenced by significant improvement in the implementation of other databases (socioeconomic for example: FAO, World Bank, IMF), which began to provide aggregated indices by country at the beginning of the 1950's.

The statistics, multiple regression models and generalized linear models, are carried out using R 2.10® (R Development Core Team, 2010). Best fit selection is carried out using the Akaike Information Criterion (AIC).

Results

Increase in the number of epidemics

The data from the GIDEON database confirm an almost exponential increase in the number of human infectious diseases producing epidemics during recent decades (Figure 1).

[1] http://www.cyinfo.com

[2] http://www.birdlife.org
[3] http://www.iucnredlist.org/initiatives/mammals
[4] ttp://www.cpc.ncep.noaa.gov

Figure 1 Increase in epidemic infectious diseases since the 1950s in Europe

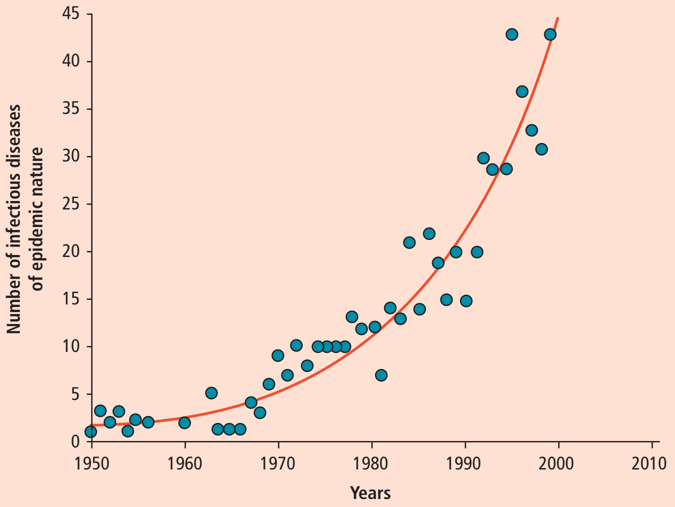
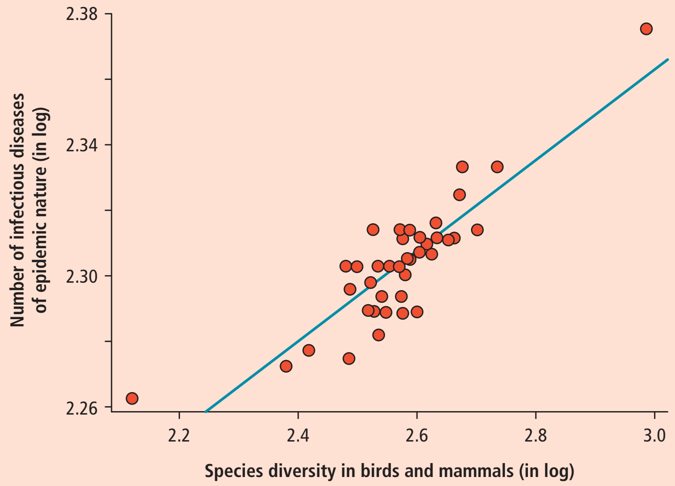


Figure 2 Relationship between the number of infectious diseases and the species diversity in birds and mammals among various European countries



Determinants of the diversity of human infectious diseases present in Europe and those which reach epidemic proportions

We carried out two multiple regression analyses, using the AIC criterion for best model selection, in order to highlight the significant explanatory factors of the total richness of total human infectious diseases reported and of these occurring as epidemics.

With respect to the total number of infectious diseases in Europe, the best model includes each country's surface area and the richness of birds and mammals therein (Table 1). It suggests that a country with a large surface area and having large biodiversity (both in terms of birds and mammals) would also have a greater variety of infectious diseases. Large biodiversity is therefore statistically proven to be an important correlative factor in terms of the diversity of human infectious diseases (Figure 2).

The number of epidemic infectious diseases can perhaps be explained by more factors. Apart from the country's surface area and biodiversity, population density and economic wealth (GDP) are also found to be statistically positively correlated while the annual variability in temperature is negatively correlated. This underlines the importance of climate variability in terms of the occurrence of epidemics.

The effect of climate variability

The influence of environmental factors, like temperature, in statistically explaining the number of epidemic infectious diseases, led us to continue our analysis by investigating the importance of climate variability in the occurrence of epidemics for 13 of the 114 infectious diseases registered throughout the last sixty years.

All 13 showed statistically positive association with the "year" factor (Table 2), reflecting the trend, mentioned above, of an increase in the number of epidemic diseases from 1950 to 2009 (Figure 1).

Table 1 Summarized results of explanatory factors of present and epidemic infectious diseases in Europe using general regression modelling (the best fit models were selected using the AIC criterion) (see also figure 2).

Infectious diseases	Explanatory variables	Effect	Probability
Total number of infectious diseases	Country surface area	+	0.02
	Diversity of species (birds & mammals)	+	<0.0001
Number of epidemic infectious diseases	Country surface area	+	0.004
	Population density	+	0.01
	Total number of infectious diseases	-	0.029
	Species diversity (birds & mammals)	+	0.003
	GDP *per capita*	+	0.0001
	Annual temperature variability	-	0.025

Six of these diseases were significantly associated with the monthly NAO index. These included adenovirus infections, Q fever, enterovirus infections, typhoid fever, tularaemia and, trichinosis. Three other diseases -viral (aseptic) meningitis, gastroenteritis and hemorrhagic fever caused by viruses in the hantavirus family- had trends associated with climate variability. The final four diseases appeared to be independent of climate variability. These were measles, tuberculosis, hepatitis A and shigellosis.

Discussion

The results presented here, although focused on European countries, are in line with analyses carried out worldwide [1]. Biodiversity would appear to be an explanatory factor for the diversity of human infectious diseases. A European country with a large biodiversity of birds and mammals would also harbor a great number of disease vectors and reservoirs which constitute the essential elements for the transmission of zoonotic diseases [6].

Table 2 Summarized results of logistic regressions on the occurrence of 13 infectious diseases in relation to year and monthly values of the North Atlantic Oscillation (NAO) index of climate variability in Europe (the best fit models were selected using the AIC criterion)

Infectious diseases	Selected variables	Estimated effect (standard error)	Probability
Adenovirus infections	Year NAO index – month of May	0.11 (0.03) 110.32 (56.46)	<0.001 0.05
Q Fever	Year NAO index of October of the previous year	0.08 (0.02) 119.82 (55.20)	0.002 0.04
Enterovirus infections	Year NAO index – month of October	0.11 (0.03) 194.30 (82.11)	<0.001 0.02
Typhoid fever	Year NAO index of December of the previous year	0.08 (0.03) 111.72 (57.94)	0.001 0.02
Trichinosis	Year NAO index – month of May NAO index – month of August	0.33 (0.11) 232.66 (99.19) -357.25 (152.04)	0.02 0.02 0.02
Gastroenteritis	Year NAO index – month of October	0.42 (0.15) 322.54 (171.11)	0.005 0.06
Viral meningitis	Year NAO index – month of August	0.08 (0.02) 18.71 (64.97)	0.001 0.07
Hemorrhagic fever caused by viruses (Hantavirus family)	Year NAO index – month of April	0.23 (0.08) 207.28 (121.68)	0.003 0.08
Tularaemia	Year NAO index – month of January	0.10 (0.03) -124.74 (58.92)	0.001 0.03
Hepatitis A	Year	0.05 (0.02)	0.006
Shigellosis	Year	0.13 (0.03)	<0.001
Measles	Year	0.21 (0.05)	<0.001
Tuberculosis	Year	0.25 (0.07)	<0.001

Biodiversity would also seem to be a factor associated with the increase in epidemic infectious diseases.

When looked at from a global point of view, these results do not contradict previous observations obtained at the local level, which show an increase in the incidence of infectious diseases with a reduction in biodiversity [4]. It must be pointed out that European biodiversity was greatly affected during the last ice age, which had reduced both mammal [12] and parasite diversities [13].

Population density that appears to be a recognized determinant of the diversity of pathogens [14] does not seem to significantly influence the diversity of infectious agents of European population. Indeed population density is used in epidemiological models as an important element when estimating the transmission rates of pathogens.

The increase in the number of epidemic diseases in Europe over the last sixty years also confirms results from studies carried out worldwide [1]. Several factors have been cited, including growing urbanization, increased resistance to antibiotics and climate change [7]. It is important to underline however, that this increase in epidemic diseases is strongly correlated with the improvements in disease detection and increased healthcare expenditures, reflected in part by the GDP positive effect. This index is certainly not the best indicator of investment in health and epidemio-surveillance. Nevertheless, work has shown that it is a good proxy of many other health indicators, including juvenile and adult mortality [15].

This first analysis of the number of epidemic and non-epidemic diseases should be considered as a first step for future work. In fact, the present study did not take into account many other factors, such as socioeconomic factors, nor had included the microbiological and genetic diversity which may hide beihind disease diagnosis.

Another important point of improvement of future studies concerns the influence of climate variability, as much on the total number of epidemic infectious diseases as on the occurrence of some of the other (non-epidemic) infectious diseases reported during the course of the last decades.

Climate variability may have a direct impact on pathogens (environmental survival, multiplication, etc.). Our results confirm that the NAO conditions could have serious implications for European public health in terms of diseases covering all types of transmission means: by aerosols, as in the case of Q fever, by water for typhoid fever, by food for trichinosis, or vector insects for tularaemia. Although effects of climate variability have already been shown in Europe for certain of these infectious diseases (with the exception of trichinosis) [10], and in particular for tularaemia in Sweden, no clear explanation of the action of climate variability on transmission has yet been presented [16].

Climate variability may act indirectly in terms of its effect on social behaviors. Accordingly the increase in the tick-borne encephalitis virus (TBE) (not tested here) appears to be associated with several factors, including increased tick survival during warmer winters and the increase of diagnosed cases resulting from greater awareness to the disease, as well as a greater number of persons present in endemic zones due to an increase in recreational activities [17;18]

Nevertheless all the results here depend on the quality of the data used, especially data which dates back to the middle of the last century. The choice of 1950 as a start date for the statistical series corresponds to the post-war period when national and international statistical databases were set up (FAO, IMF, World Bank, WHO).

The results presented here have two major implications for epidemio-surveillance. The effect of biodiversity on infectious diseases suggests that higher-resolution studies, both geographic and temporal, are needed to inform it.

In this way, we could, for example, study the statistical relations between the changing uses of land (fragmentation on landscape, increasing or reducing forest areas) and the occurrence of epidemics in order to investigate different scenarios for the effects of changes in biodiversity on infectious risks. Second, the continuing increases of climate variability, as shown by the NAO index [19] could potentially increase the risks of epidemics in the near future. Nevertheless more in-depth studies are necessary before proposing the use of climate variability in early-warning systems.

Acknowledgements

This study is supported by the ERA-NET ENHanCe project (http://www.liv.ac.uk/enhance/) and by ATP Cirad "Health emergences and risks". We would like to thank Katie Owend for her involvement in the construction of the database.

References

[1] Jones KE, Patel NG, Levy MA, Storeygard A, Balk D, Gittleman JL, *et al.* Global trends in emerging infectious diseases. Nature. 2008;451:990-4.

[2] Lafferty KD. The ecology of climate change and infectious diseases. Ecology. 2009;90:888-900.

[3] Harvell CD, Mitchell CE, Ward JR, Altizer S, Dobson AP, Ostfeld RS, *et al.* Climate warming and disease risks for terrestrial and marine biota. Science. 2002;296: 2158-62.

[4] Keesing F, Belden LK, Daszak P, Dobson A, Harvell CD, Holt RD, *et al.* Impacts of biodiversity on the emergence and transmission of infectious diseases. Nature. 2010;468:647-52.

[5] Guernier V, Hochberg ME, Guégan JF. Ecology drives the worldwide distribution of human diseases. Plos Biol. 2004;2:740-6.

[6] Dunn RR, Davies TJ, Harris NC, Gavin MC. Global drivers of human pathogen richness and prevalence. Proc R Soc B Biol Sc. 2010;277:2587-95.

[7] Semenza JC, Menne B. Climate change and infectious diseases in Europe. Lancet Infect Dis. 2009;9:365–75.

[8] Purse BV, Mellor PS, Rogers DJ, Samuel AR, Mertens PPC, Baylis M. Climate change and the recent emergence of bluetongue in Europe. Nature Rev Microbiol. 2005;3:171-81.

[9] McIntyre KM, Setzkorn C, Baylis M, Waret-Szkuta A, Caminade C, Morse AP, *et al.* Impact of climate change on human and animal health. Vet Rec. 2010;167(15):586.

[10] Hubálek Z. North Atlantic weather oscillation and human infectious diseases in the Czech Republic, 1951–2003. Eur J Epidemiol. 2005;20:263-72.

[11] Guis H, Caminade C, Calvete C, Morse AP, Tran A, Baylis M. Modelling the effects of past and future climate on the risk of bluetongue emergence in Europe. J R Soc Interface. 2012;9(67):339-50.

[12] Sara M, Morand S. Island incidence and mainland population density: mammals from Mediterranean islands. Div Dist. 2002;8:1-10.

[13] Goüy de Bellocq J, Morand S, Feliu C. Patterns of parasite species richness of Western Palaeartic: micro-mammals: island effects. Ecography. 2002;25:173-83.

[14] Poulin R, Morand S. The parasite biodiversity. Washington: Smithsonian Institution Press, 2004.

[15] Martens P, Akin S-M, Huynen M, Mohsin R. Is globalization healthy: a statistical indicator analysis of the impacts of globalization on health. Global Health. 2010;6:16.

[16] Rydén P, Sjöstedt A, Johansson A. Effects of climate change on tularaemia disease activity in Sweden. Glob Health Action. 2009;2. doi: 10.3402/gha.v2i0.2063.

[17] Randolph SE. Tick-borne encephalitis virus, ticks and humans: short-term and long-term dynamics. Curr Opin Infect Dis. 2008;462:467.

[18] Evengård B, Sauerborn R. Climate change influences infectious diseases both in the Arctic and the tropics: joining the dots. Glob Health Action. 2009;2. doi: 10.3402/gha.v2i0.2106.

[19] Visbeck MH, Hurrell JW, Polvani L, Cullen HM. The North Atlantic Oscillation: Past, present, and future. Proc Natl Acad Sci USA. 2001;98:12876-7.

How to cite this article: Morand S, Waret-Szkuta A. Les déterminants des maladies infectieuses humaines en Europe : influences de la biodiversité et de la variabilité climatique. [Determinants of human infectious diseases in Europe: biodiversity and climate variability influences].Bull Epidémiol Hebd. 2012;(12-13):156-9.

Box - Public health surveillance: anticipation and detection of emerging infectious diseases in the context of climate change

Dounia Bitar (d.bitar@invs.sante.fr)**, Didier Che, Henriette De Valk**

Institut de veille sanitaire, Saint-Maurice, France

Many researchers and experts regularly draw the attention of health authorities to the possible emergence or re-emergence of infectious diseases because of climate change (CC). Nevertheless, some among them relativize the role played by CC by stressing the multiplicity of determinants which lead to the emergence of infectious diseases [1;2]. Against this background, in 2009 we evaluated the French Institute for Public Health Surveillance's (Institut de Veille Sanitaire - InVS) state of preparedness for the possible emergence of infectious diseases associated with CC [3].

From a preliminary inventory [4], 21 pathogens and groups of pathogens were identified as being potentially impacted by climate change. A scale of criteria was applied, based on the impact of each human infectious disease (incidence or prevalence, severity, mortality, epidemic potential, means of transmission, existence of prevention and control measures), the impact of infections or carrier state in animals (in the case of zoonosis), as well as the determinants associated with the environmental context (including CC).

The first question investigated concerned the capacity of our surveillance systems to identify epidemiological changes potentially associated with CC (incidence increase, change in at-risk groups, etc.). The current organisation for infectious diseases includes specific (by pathogen) and non-specific (syndromic) surveillance, as well as a reporting system for emerging phenomena occurring on national territory or likely to be imported [5]. To date, these systems appear to be sufficient for identifying increases in cases and epidemiological modifications, and, when needed, for issuing an alert. Moreover, they are already integrated in the existing preparedness and response plans. For example, in mainland France, the plan to prevent the spread of dengue fever and chikungunya [6] is updated each year according to changes in epidemiological and entomological data, notably the period of activity of the *Aedes* vector (currently May to November, but this period may change in the future because of CC) and the extension of its habitat area. The plan aims to detect cases as soon as there is any suspicion and to organize, as quickly as possible, control measures around these cases in order to limit secondary spread. In the context of this surveillance system, two emergences of the diseases were identified in 2010, respectively: 2 autochthonous cases of dengue fever in Nice (Alpes-Maritimes area) and 2 non-imported cases of chikungunya in Fréjus (Var area). The investigation showed that imported cases, reported late and therefore escaping control measures, lay at the origin of these non-imported cases. This example shows that the climate factor is an important criterion in risk analysis but that the specific role of CC in the emergence of these non-imported cases cannot be disassociated from other factors, for example international travels (importation of viremic cases) or the efficacy of surveillance systems (delay in reporting the first cases) and vector control.

The second question investigated concerned the link between the anticipatory approach (early-warning systems), which aims at detecting risks, and the surveillance of effects, which aims at detecting cases. For example, increased surveillance of the levels of *Legionella* in cooling towers during the summer period could reduce the risk of occurrence of infection in humans, by providing information, issuing alerts and implementing environmental checks when thresholds are exceeded. But the efficiency of this risk reduction strategy (reducing exposure) compared with the number of cases avoided still remains to be evaluated.

Finally, in the long term, research projects - including sophisticated models - will enable the InVS to better prioritize the risks linked to CC and to adapt early-warning and surveillance systems. In this priorisation process, the CC factor should be given equal importance as the other factors (environmental, social, demographic, economic, etc) which contribute to the emergence of infectious diseases.

References

[1] Woolhouse ME, Gowtage-Sequeria S. Host range and emerging and reemerging pathogens. Emerg Infect Dis. 2005;11(12):1842-7.

[2] Randolph SE. Dynamics of tick-borne disease systems: minor role of recent climate change. Rev Sci Tech. 2008;27(2):367-81.

[3] Pascal M. Impacts sanitaires du changement climatique en France. Quels enjeux pour l'InVS ? Saint-Maurice: Institut de veille sanitaire; 2010; 55 p. Available at: http://www.invs.sante.fr/pmb/invs/(id)/PMB_721

[4] Ministère de la Santé. Les effets qualitatifs du changement climatique sur la santé en France. Rapport de groupe interministériel, 2008. Available at: http://www.sante.gouv.fr/changement-climatique.html

[5] Bitar D, Che D, Capek I, De Valk H, Saura C. Veille sanitaire et appréciation du risque infectieux émergent : méthode et critères d'analyse du risque. Med Mal Infect. 2011;41(2):53-62.

[6] Direction Générale de la Santé. Plan national anti-dissémination du chikungunya et de la dengue. Paris: Mi nistère de la Santé. 2010; 53 p. Available at: http://www.sante.gouv.fr/IMG/pdf/plan_antidissemination_dengue_chikungunya_2010-2.pdf

How to cite this article: Bitar D, Che D, de Valk H. Encadré : Veille sanitaire : anticipation et détection des maladies infectieuses émergentes dans le contexte du changement climatique. [Box : Public health surveillance: anticipation and detection of emerging infectious diseases in the context of climate change].Bull Epidémiol Hebd. 2012;(12-13):160.

Retrouvez ce numéro ainsi que les archives du Bulletin épidémiologique hebdomadaire sur http://www.invs.sante.fr/Publications-et-outils/BEH-Bulletin-epidemiologique-hebdomadaire

Directrice de la publication : Dr Françoise Weber, directrice générale de l'InVS
Rédactrice en chef : Judith Benrekassa, InVS, redactionBEH@invs.sante.fr
Rédactrice en chef adjointe : Laetitia Gouffé-Benadiba
Secrétaire de rédaction : Farida Mihoub

Institut de veille sanitaire - Site Internet : http://www.invs.sante.fr

Prépresse : Imprimerie Centrale, 15, rue du Commerce, L-1351 Luxembourg
N° INPI : 00 300 1836 - ISSN 0245-7466